

the U.S. Patent and Trademark Office" in the amount of \$65.00 for a small entity is enclosed.

For allowance of claims 21, 23, 24, and 29, a terminal disclaimer has been filed. Claims 25, 26 and 28 are withdrawn and no longer pending in this application. The Examiner has rejected claim 21 so it is amended to include the substance of cancelled claim 22 and they are cancelled. Dependent claims 22 and 27 are objected to by the Examiner. Claim 1 is cancelled. Dependent claim 27 has been amended to depend from amended claim 21. Dependent claims 23 and 24 depend from amended claim 21.

The Examiner rejects claim 1 on the newly cited Yew patent 3,599,954 under 35 USC 102 herein after the '954 patent. The '954 patent disclosure is cited by the Examiner with reference to the teachings of a vacuum suspension system within a coil load spring used for static height control and damping from jounce to rebound. Applicant has cancelled claim 1.

Applicant has as requested by the Examiner corrected the drawings and the detailed description so reference numbers 18 and 19 no longer appear. Applicant has amended the claims to overcome the objection and rejection and has submitted the required terminal disclaimer and fee. Claims 25, 26 and 28 have been withdrawn. The amended remaining claims should be allowed.

Should there be any questions, the Examiner is encouraged to call or email the Applicant's undersigned attorney.

Respectfully submitted on behalf of Applicant for reconsideration,



Aaron Passman Registration Number 26,783

9632 Windom Point Avenue

Las Vegas, Nevada 89129

(702) 341-9066

apassman@aol.com

13 is resisting the motion of the chassis and body 11 away from the wheel axle support 12. Heretofore the suspension designers goal was to minimize the unsprung weight 13 relative to the sprung weight 11 to reduce momentum effects of the wheel axle support 12 in motion. Thus, no one had thought to use the weight thereof to oppose sway (roll) or pitch of the chassis and body 11. Consequently, the resilient member 16 has a free length of travel that operates in cooperation with the resilient load bolster 15 jounce deflection so the free length of travel and the jounce deflection overlap when the resilient member 16 moves between the chassis 11 and the wheel axle support 12.

The chassis 11 has a substantially rectangular footprint having four wheels disposed generally to carry the corners thereof with each corner having its wheel axle support 12 moveably carried by its resilient load bolster 15 and its resilient member 16 to resist jounce and rebound, respectively see Figure 12. A shock absorber 17 can be located between and affixed to the chassis 11 for each wheel axle support 12 for damping the jounce and rebound motions there between progressively decreasing the frequency of the wheel axle support 12 motion, Figure 3. The shock absorber 17 can be coupled to the resilient load bolster 15 and/or the resilient member 16 as a coil over system or a coil in line suspension, see Figures 7 and 10. Also the shock absorber 17 can be free standing separated from the opposed resilient load bolster 15 and resilient member 16 and positioned to maximize its dampening effects and simplify its replacement, since that is conventional it is shown in Figures 7 and 8. Regarding the latter, McPherson struts combine the load carrying, shock absorber and the turning functions in one complex assembly, Figure 10 shows that sort of suspension with opposed springs. The opposed spring suspension 14 can be adapted to that as will be shown and described herein. All kinds of suspension layouts can be used with the opposed spring suspension 14.

Figure 3 is a front view of the opposed spring suspension 14 having coil compression and tension springs 15 and 16 respectively mounted coaxial and concentrically in an assembled 20 relationship and for clarity the respective coil springs 15 and 16 are shown individually aside the assembly 20. The resilient

member 16 therein is coil spring 16 having its free length of travel preloaded with tension sufficient to maintain its connection between the chassis 11 and the wheel axle support 12 even when the resilient load bolster 15 is compressed to its maximum load capacity, see its separate showings in Figure 3. The resilient member 16 alternatively is in Figure 5 an elastic member 21 having its free length of travel stretched sufficiently between the chassis 11 and the wheel axle support 12 to attach thereto even when the resilient load bolster 15 is compressed to its maximum load capacity.

The resilient member 16 could be a torsion spring as in Figure 6 with torque preloaded sufficiently between the chassis 11 and the wheel axle support 12 to maintain connection there between even when the resilient load bolster 15, if used, is compressed to its maximum load capacity. Typically torsion springs 22 or 22' are pre-twisted to carry the intended static load at a neutral position whereby further load such as jounce will not exceed the ultimate stress and cause permanent deformation of the torsion bar 22 in Figure 6.

Thus, the concept of overlapping travel as discussed and depicted in the graph of Figure 2 is not inherent in a single torsion bar or for that matter any other spring suspension even though stretched during rebound movement. In Figure 6 the load support is shown as two distinct torsion bars 22 and 22' each with a pre-twisted and preloaded to carry either jounce or rebound. Skilled spring makers understand how to make torsion bars 22 or 22' that will provide the load curves of Figure 2.

The resilient load bolster 15 preferably has an elastic constant of  $K$  to carry sprung weight on the wheel axle support 12 and the resilient member 16 has an elastic constant  $K_r$  for resisting the rebound motion of the sprung weight 11 over the wheel axle support 12. The relationship of the elastic constant of  $K$  to carry sprung weight 11 for jounce and the elastic constant  $K_r$  for resisting the rebound motion of the unsprung weight 13 is a function of the amount of roll resistance desired. While a particular example is explained and plotted in Figure 2, adjustments to the spring constants and travel can be made to adjust for the chassis 11 load for the ride height and the desired stiffness and travel required.

The vehicle opposed spring system 14 is placed between chassis 11 as sprung weight and a plurality of wheel axle supports 12 each carrying a portion of an unsprung weight 13. The opposed spring system 14 preferably has coil load spring 15 mounted between the chassis 11 and each wheel axle support 12 to carry when preloaded the chassis 11 at a preset ride height relative to each wheel axle support 12 in Figures 3, 4, 5, 7, 8, 9 and 10. The coil tension spring 16 of Figures 3, 4, 5 and 11 is affixed between each wheel axle support 12 and the chassis 11 and it exerts increasing force thereat as a function of the amount of rebound motion of the unsprung weight 13 relative to the chassis 11. The coil tension spring 16 mounts relative to the coil load spring 15 for stretching between the chassis 11 and the wheel axle support 12 in Figure 3. The coil tension spring 16 applies increasingly less rebound force to the coil load spring 15 during jounce through and beyond the preset ride height of the coil load spring 15 as each coil tension spring 16 resists the rebound motion of sprung weight 13 at each wheel axle support 12, as shown graphically in Figure 2.

Each coil load spring 15 is coaxial with its respective load spring axis 23 disposed approximately normal to the chassis 11 and each wheel axle support 12, as shown in the assembled arrangement in Figure 3. Each coil load spring 15 has a concentric volume 24 defined thereby and located there within for disposition of its coil tension spring 16 there within its concentric volume 24 for movement therein without binding with the coil load spring 15 during jounce and rebound.

Each coil load spring 15 is coaxial with load spring axis 23 and approximately normal to the chassis 11, for each wheel axle support 12. A coil tension spring 16 can, as in Figure 4 be spaced apart from the coil load spring 15 along a tension spring axis 25 generally parallel to the load spring axis 23 of each coil load spring 15. Thus, each coil tension spring 16 may move relative to its respective coil load spring 15 during jounce and rebound as in Figure 4.

A plurality of coil control springs 16 can be affixed between each wheel axle support 12 and the chassis 11 for exerting increasing force thereat as a function of the amount of rebound motion of the sprung weight relative of the chassis 11.

Each coil control spring 16 can oppose its respective coil load spring 15 applying increasingly less rebound force thereto during jounce through and beyond the preset ride height of the coil load spring 15 as each respective coil control spring 16 resists the rebound motion of unsprung weight over its respective wheel axle support 12. In for example Figure 9 a general arrangement of two compression springs 15 and 16 with a platform 26 in Figures 7, 8, 9 and 10 there between can be used as shown or in a McPherson strut arrangement Figure 10 for steering as well. Paths are defined by each of the lines between the chassis 11 and the wheel axle support 12 for the plural opposed spring assemblies 16 shown in Figure 12. Along each path each coil load spring 15 and its respective coil control spring 16 jounce and rebound following the line there along as each wheel axle support 12 follows its controlled travel. Each coil control spring 16 has a free length of travel that cooperates with the coil load spring 15 jounce deflection along the line of the path so the free length of travel and the jounce deflection overlap, see Figure 2 for a graphic showing.

In operation of the opposed suspension 14 of Figure 9, each wheel axle support 12 includes a rod 27 fixed to the chassis 11 extending along line 28 for supporting the suspension platform 26 see Figures 9 and 10. Each suspension platform 26 is disposed in compression and for reciprocation along the path 28 with and between the coil load spring 15 and the coil control spring 16 during jounce and rebound and the suspension platform 26 is affixed to the wheel axle support 12. Thus, two coil springs 15 and 16 in compression support the chassis and body with a compact arrangement of the opposed spring suspension 14.

Comparison of the standard vehicle roll formula to a new one including an added tension spring may be best understood with reference to Figures 1 and 2 wherein the terms used hereafter are illustrated and the effects of opposed springs 14 are graphically shown. Thus, Figure 1 is a schematic representation of an axle as seen in front view with the parameters of the formula disclosed.

The standard formula for vehicle roll equals:

$2 \times G \times \text{Suspension Height} / \text{Suspension Width} \times \text{Spring Load} / \text{Spring Rate}$

In this formula:

G is the gravitational force.

Suspension Height = the distance between the axle center-line and the center of gravity (CG).

Suspension Width equals the distance between spring centers.

In the example calculation below: spring load = 800 pounds and spring rate is 100 pounds per inch.

$\text{Roll} = 2 \times .75 \times 12/48 \times 800/100 = 3"$  measured at each spring center for a differential of 6 inches. This is equivalent to approximately 3.5 degrees of roll or twist about the roll center. In this example the body rolled as if the vehicle were rounding a curve such that the compressing of the outer spring and the decompressing of the inner spring were finally neutralized by the centrifugal displacement of the mass.

In the opposed spring system 14 tension spring 16 is positioned either alongside or along the central axis 23 of the compression spring 15 so that the tension spring 16 travels the same path 23 as the compression spring 15. For example, tension spring 16 with a rate of 75 pounds per inch deployed so it stretches an equal amount to the compression spring 15 travel from its free height reacts against the compression spring 15 at normal ride height. Modifying the formula for body roll to include the reaction caused by the tension spring.

The formula for roll equals:

$$2G \times \text{Suspension Height} / \text{Suspension Weight} \times 2\text{Spring Load} / (2K + KT)$$

Here there are two Spring Rates, K is the load spring rate per inch and KT is the tension spring rate per inch.

The relative reduction in body roll equals  $2K/2(K + KT)$

and, using the previous example values gives a new resultant body roll of 2 152"

Using this formula:

To reduce the body roll or pitch by 50 percent then KT equals 2K so the roll is halved when the rate of the tension spring 16 equals half the rate of the compression spring 15. Subject to the mass of the unsprung weight 13. Thus demonstrating the effectiveness of using opposing springs 14 to offset the rolling mass of the chassis and body 11 above that axle 12 and for the first time in

automotive history also demonstrating a potential benefit of increase in unsprung weight 13.

A method of using the opposed suspension 14 with steps of mounting the bolster 15 between the chassis 11 and the wheel axle support 12 for carrying it when preloaded a preset ride height, affixing resilient member 16 between each wheel axle support 12 and the chassis 11 for exerting increasing force there between as a function of the amount of motion of the unsprung weight 13 relative to the chassis 11, and mounting the resilient member 16 for movement between the chassis 11 and the wheel axle support 12 while applying increasingly less force to the resilient load bolster 15 during jounce while under loading beyond the preloaded at the chassis 11 preset ride height of the resilient load bolster 15 and the resilient member 16 applying increasingly more force resisting the motion of unsprung weight 13 on the wheel axle support 12.

In operation the primary difference, between the opposed spring suspension 14 and existing load carrying spring suspensions, is the involvement of the unsprung mass 13 (i.e. axle/wheels) for controlling the dynamics of the vehicle during cornering. Besides the opposing suspension system 14 at all four corners trying to keep the vehicle level relative to the ground, the unsprung axles now actively participant by virtue of their role as countering mass. Similarly the unsprung masses (front and rear) will also resist forward and aft pitching while braking or accelerating, respectively.

It should be noted:

That wherever there are two compression springs 15 and 16 used, a tension type spring 16 might often be utilized in place of one or both of them. In all the various methods of achieving opposed suspension 14, standard automotive shock absorbers can be incorporated to dampen wheel bounce. The opposing spring suspension 14 is a suspension system that is height controlling and has progressive load carrying capability. There are many ways to achieve the resistance to roll of the chassis 11 using opposing spring suspension 14.

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Here there are two Spring Rates, K is the load spring rate per inch and KT is the tension spring rate per inch.

The relative reduction in body roll equals  $2K/2(K + KT)$

and, using the previous example values gives a new resultant body roll of 2 .152"

Using this formula:

To reduce the body roll or pitch by 50 percent then  $KT$  equals  $2K$  so the roll is halved when the rate of the tension spring 49 16 equals half the rate of the compression spring 48 15. Subject to the mass of the unsprung weight 13. Thus demonstrating the effectiveness of using opposing springs 14 to offset the rolling mass of the chassis and body 11 above that axle 12 and for the first time in automotive history also demonstrating a potential benefit of increase in unsprung weight 13.

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CORRECTIONS IN RED

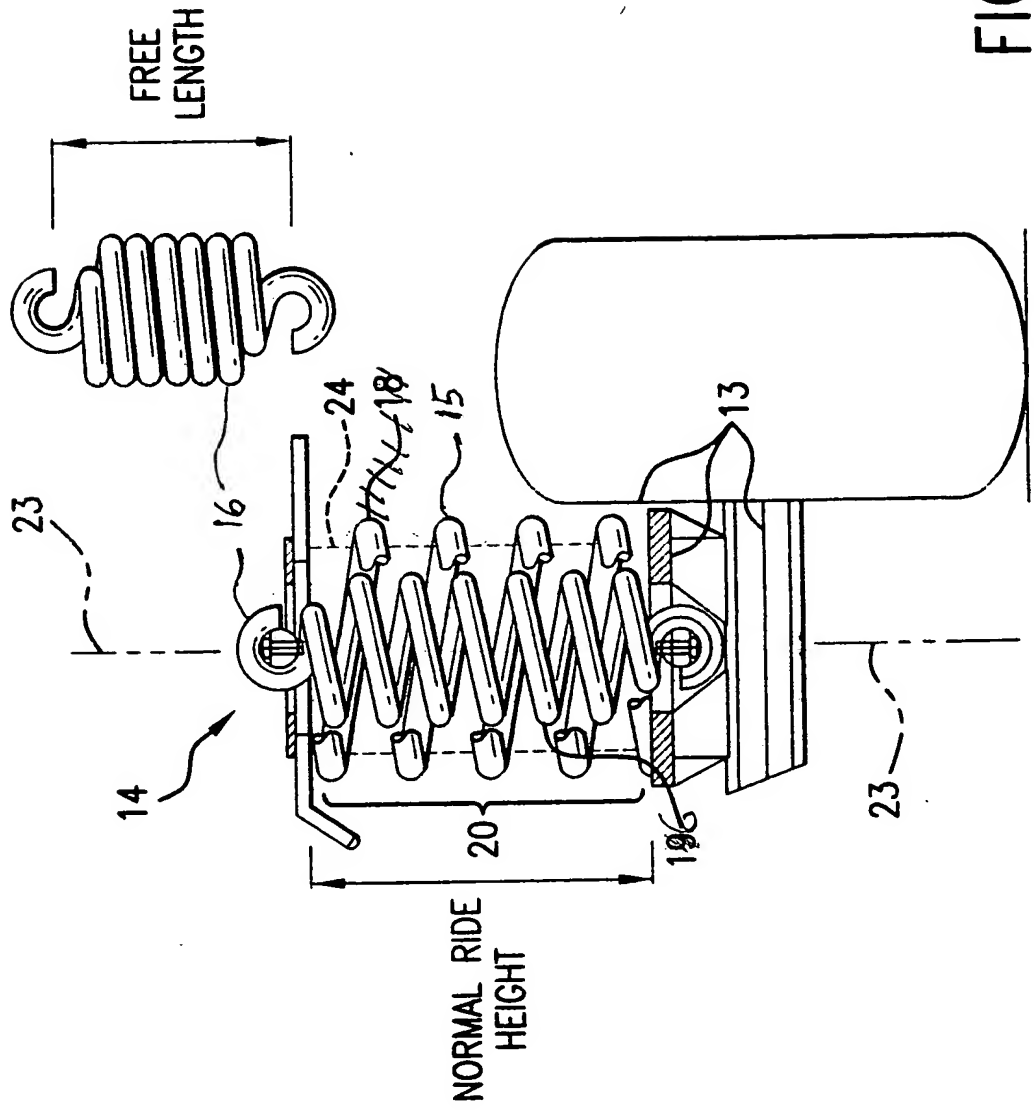
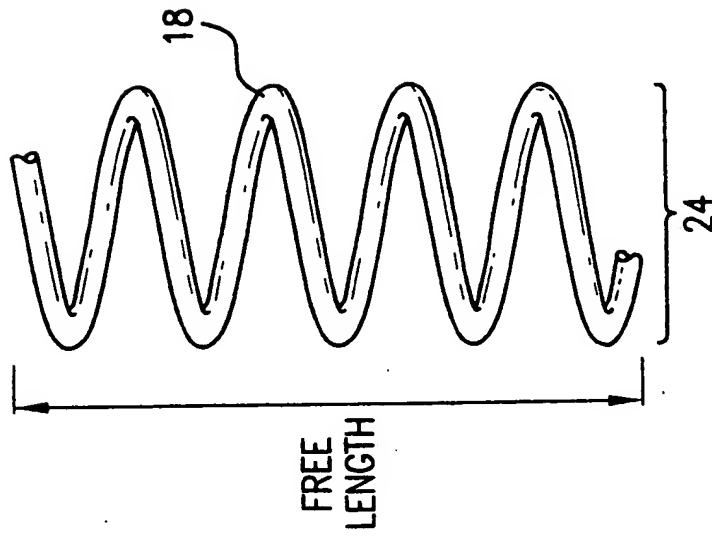


FIG. 3

CORRECTIONS IN RED

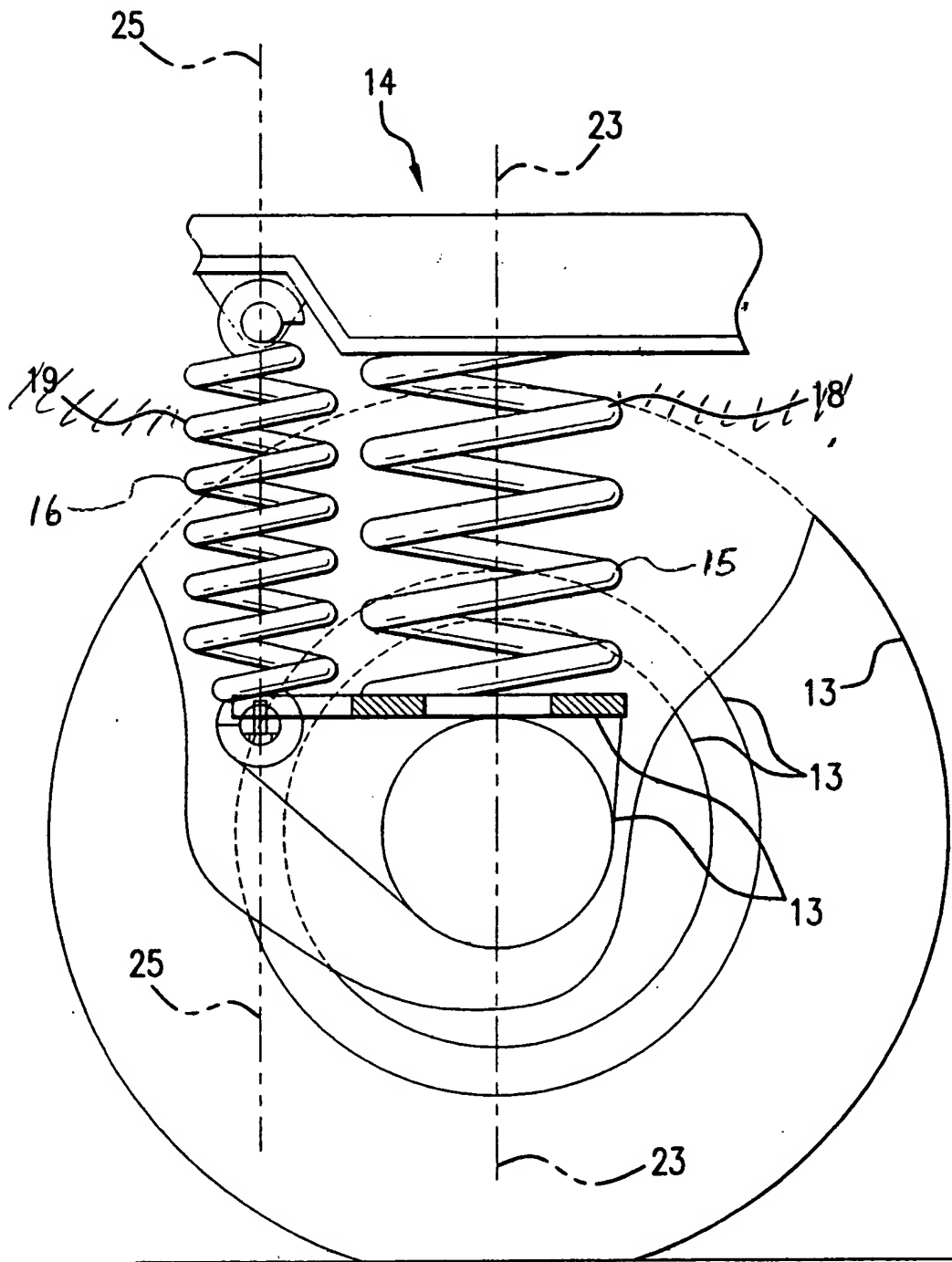


FIG.4



CORRECTIONS IN RED

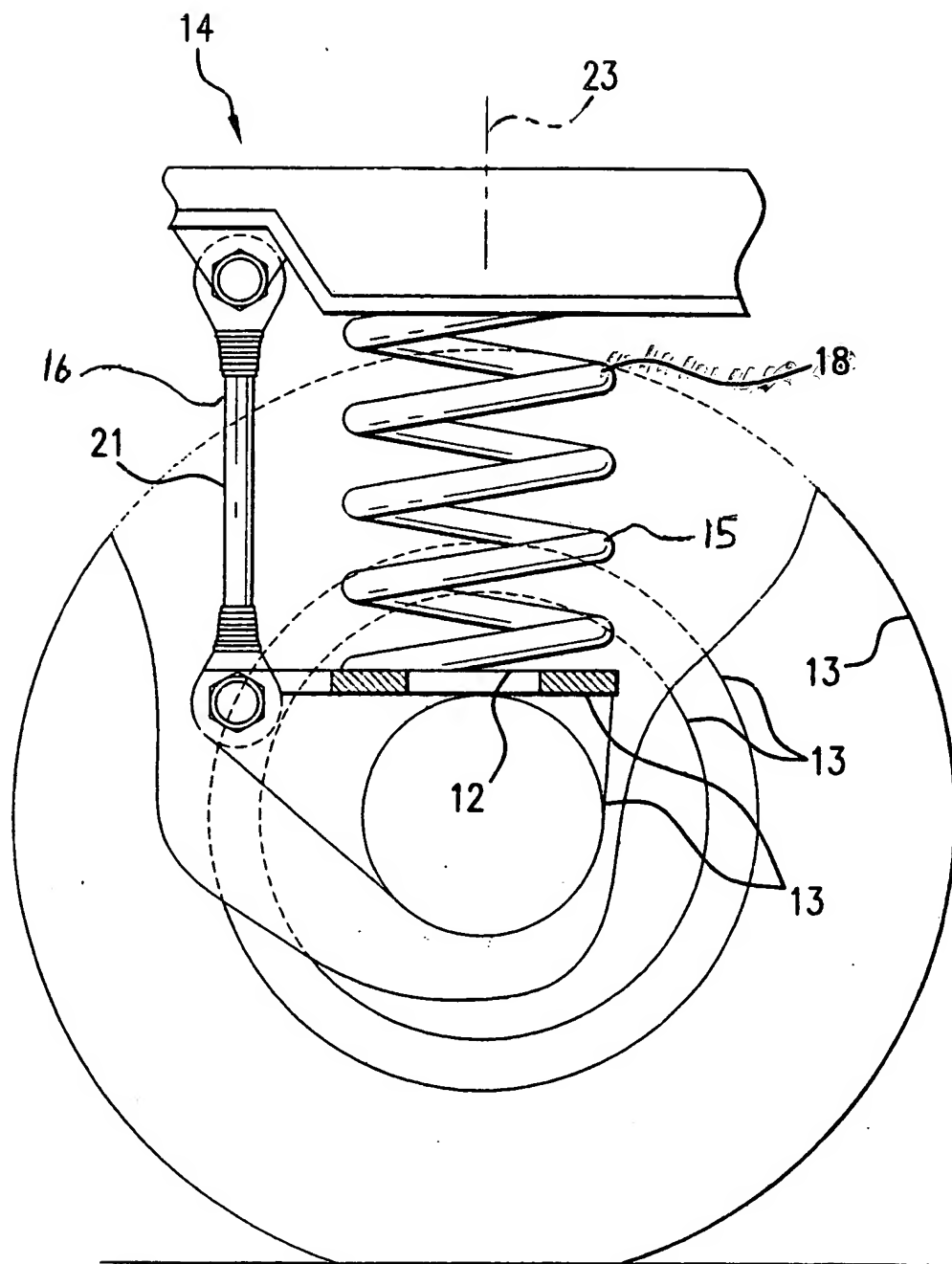


FIG.5

CORRECTIONS IN RED

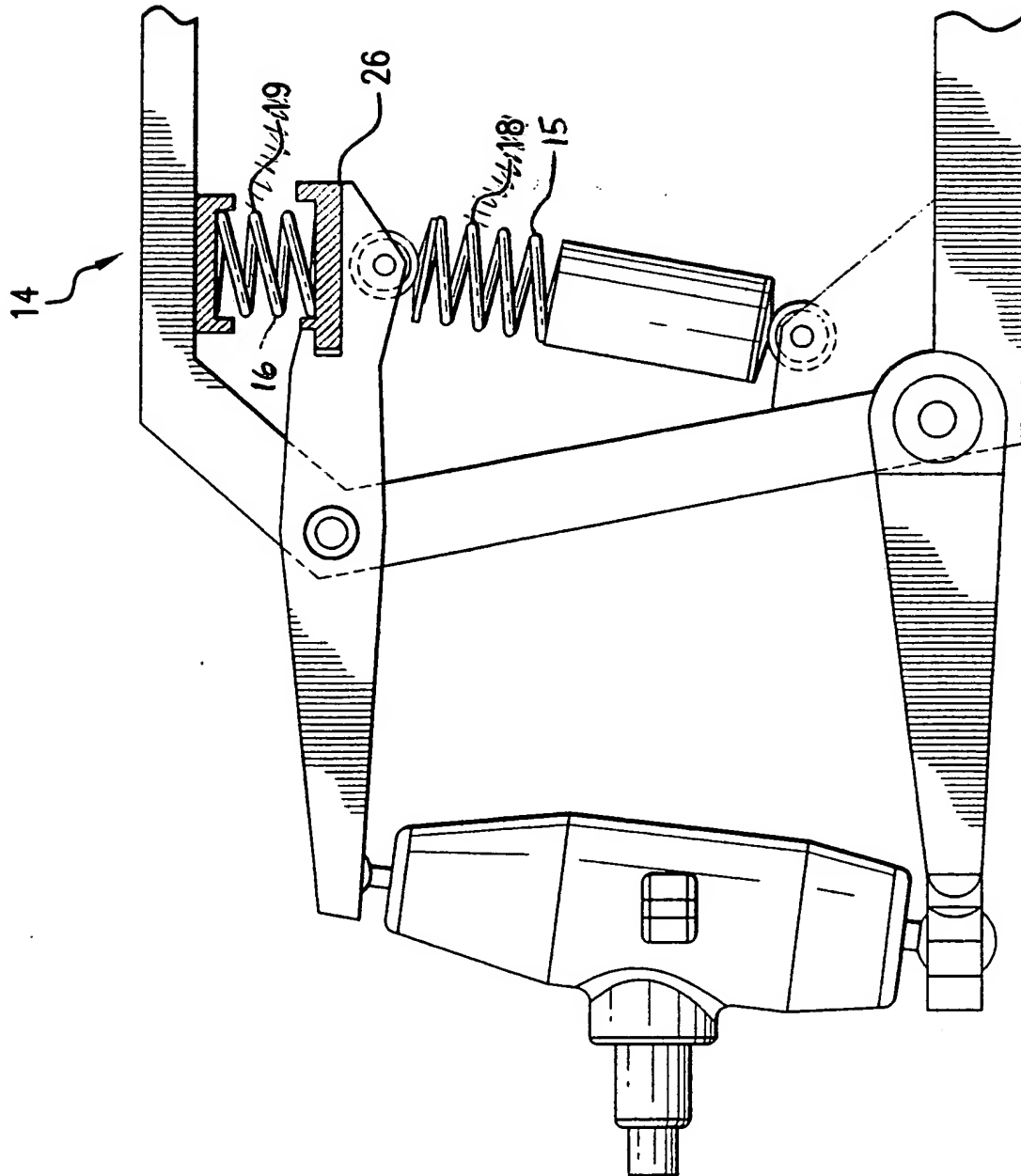


FIG.7

CORRECTIONS IN RED

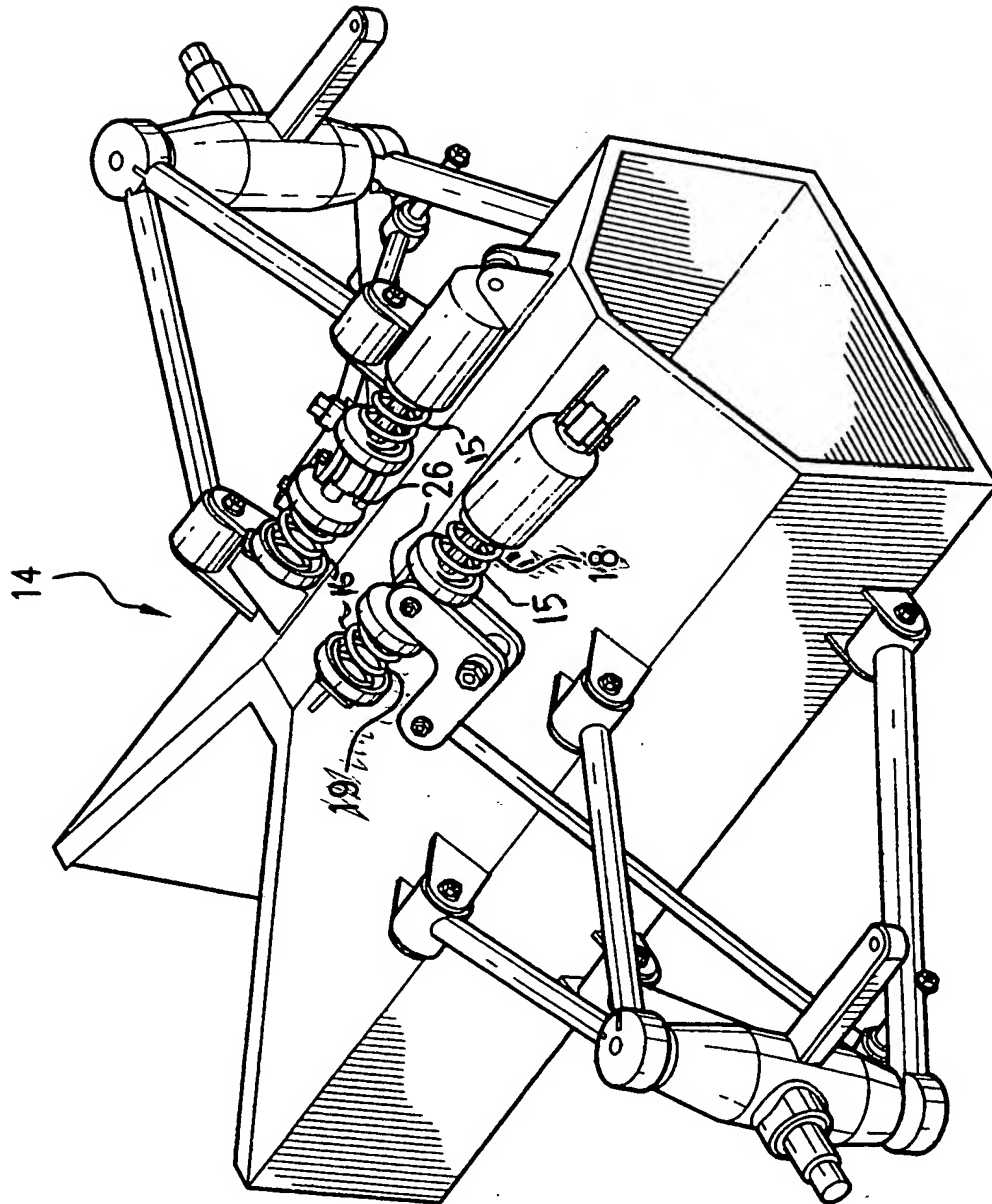


FIG.8

CORRECTIONS IN RED

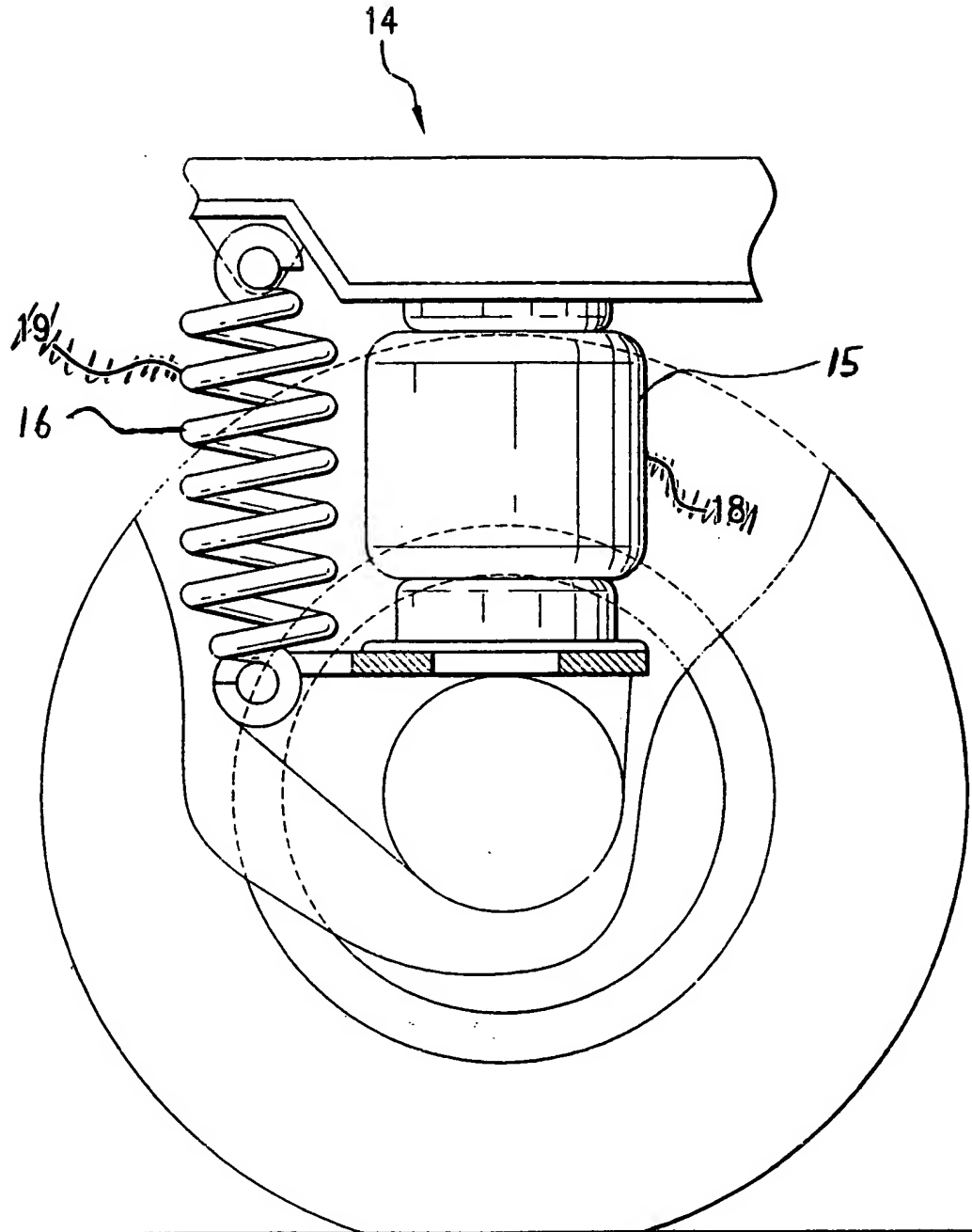


FIG. 11